How Can Emissions Inventories be Improved for Source Apportionment and Health Associations?
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research and development

Science Questions

Air quality management and science, and protection of public health, rely on our ability to accurately identify source impacts on air quality. Two primary classes of approaches have been used historically: receptor-based and emissions-based models. Here, we use utilize both, as well as a hybrid of the two to address a series of questions:
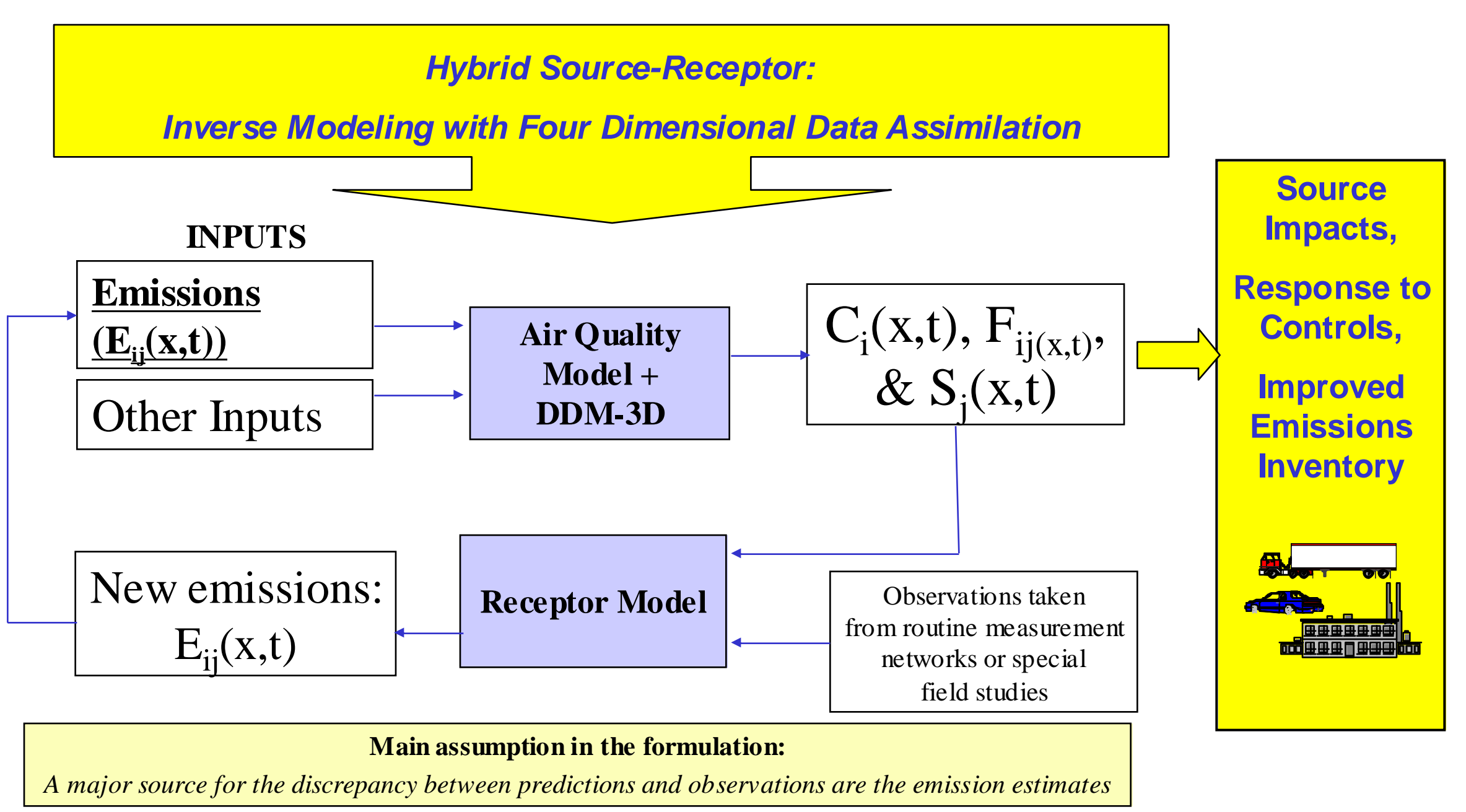
• What are their strengths and weaknesses?

• What uncertainties are involved and result?

• What are the biases of current emissions inventories?

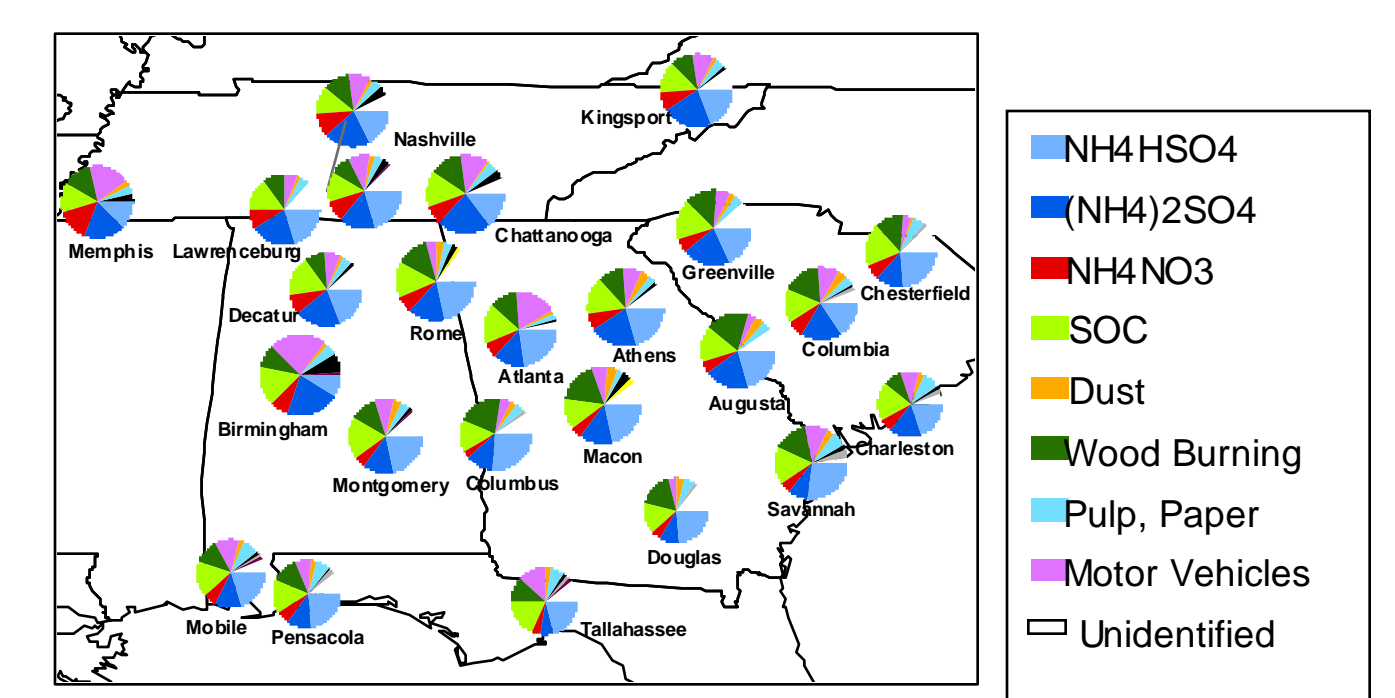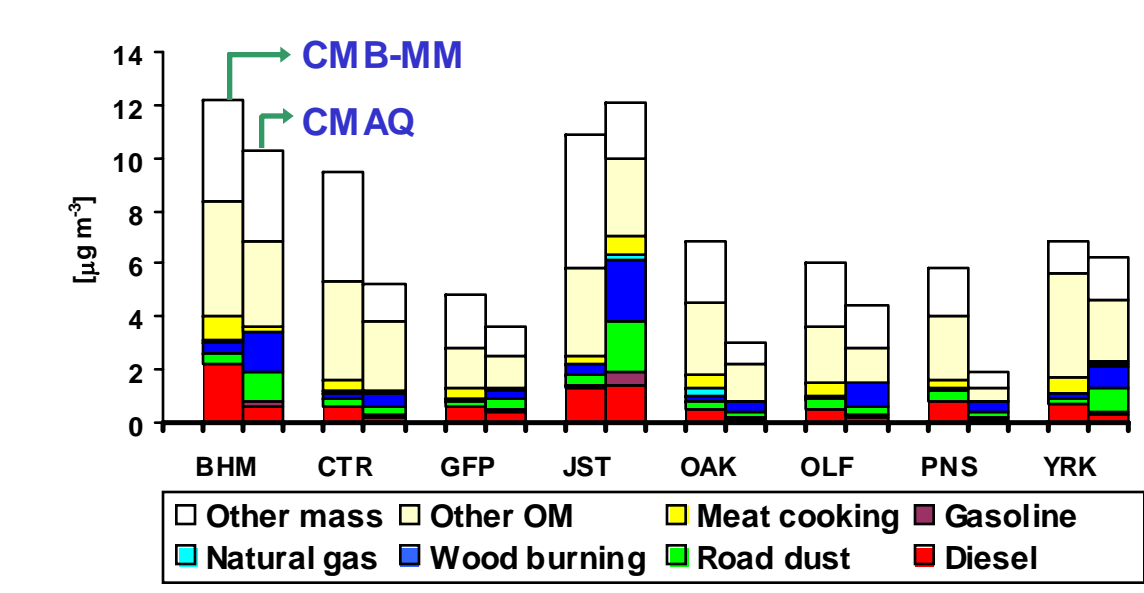• How should these models be used to help link sources with health effects?
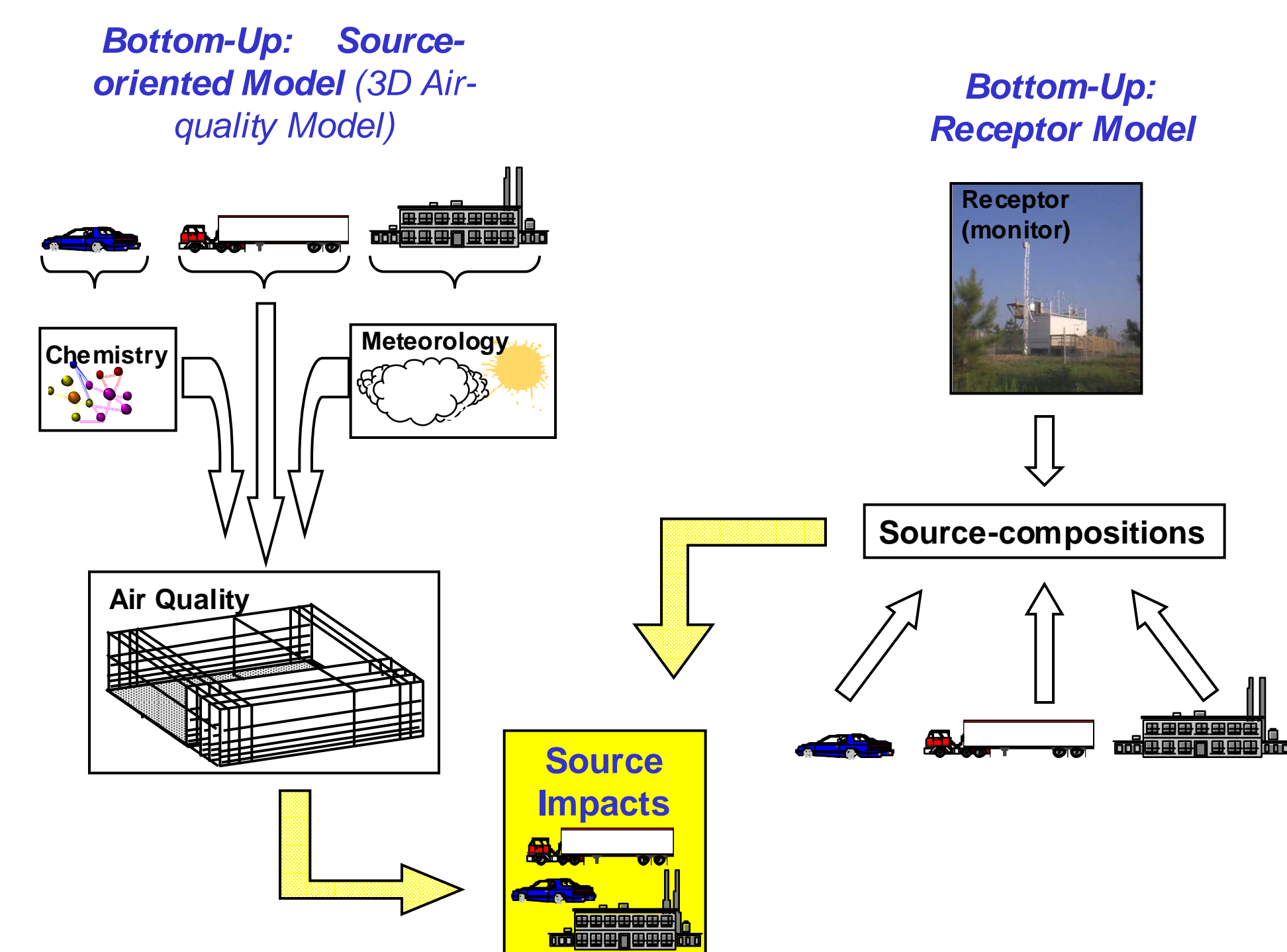
Research Goals

• Provide quantitative estimates of emissions inventory uncertainties and biases, and correct biases.

• Provide quantitative estimates of source-impact estimates from various modeling techniques currently being used in air quality management, including:
  • Chemical Mass Balance Models (CMB-MM)
  • Positive Matrix Factorization (PMF)
  • Community Multiscale Air Quality Model (CMAQ)

• Provide source impact and uncertainty information to health effects researchers for epidemiologic analyses.

Methods/Approach

Bottom-Up: Source-oriented Model (3D Air-quality Model)

Chemistry   Meteorology

Air Quality

Source Impacts

Bottom-Up: Receptor Model

Receptor (monitor)

Source-compositions

Hybrid Source-Receptor:
Inverse Modeling with Four Dimensional Data Assimilation

INPUTS

Emissions $(E_{ij}(x,t))$ → Air Quality Model + DDM-3D → $C_i(x,t)$, $F_{ij(x,t)}$, & $S_i(x,t)$ → Source Impacts, Response to Controls, Improved Emissions Inventory

Other Inputs

New emissions: $E_{ij}(x,t)$ ← Receptor Model ← Observations taken from routine measurement networks or special field studies

Main assumption in the formulation:
A major source for the discrepancy between predictions and observations are the emission estimates

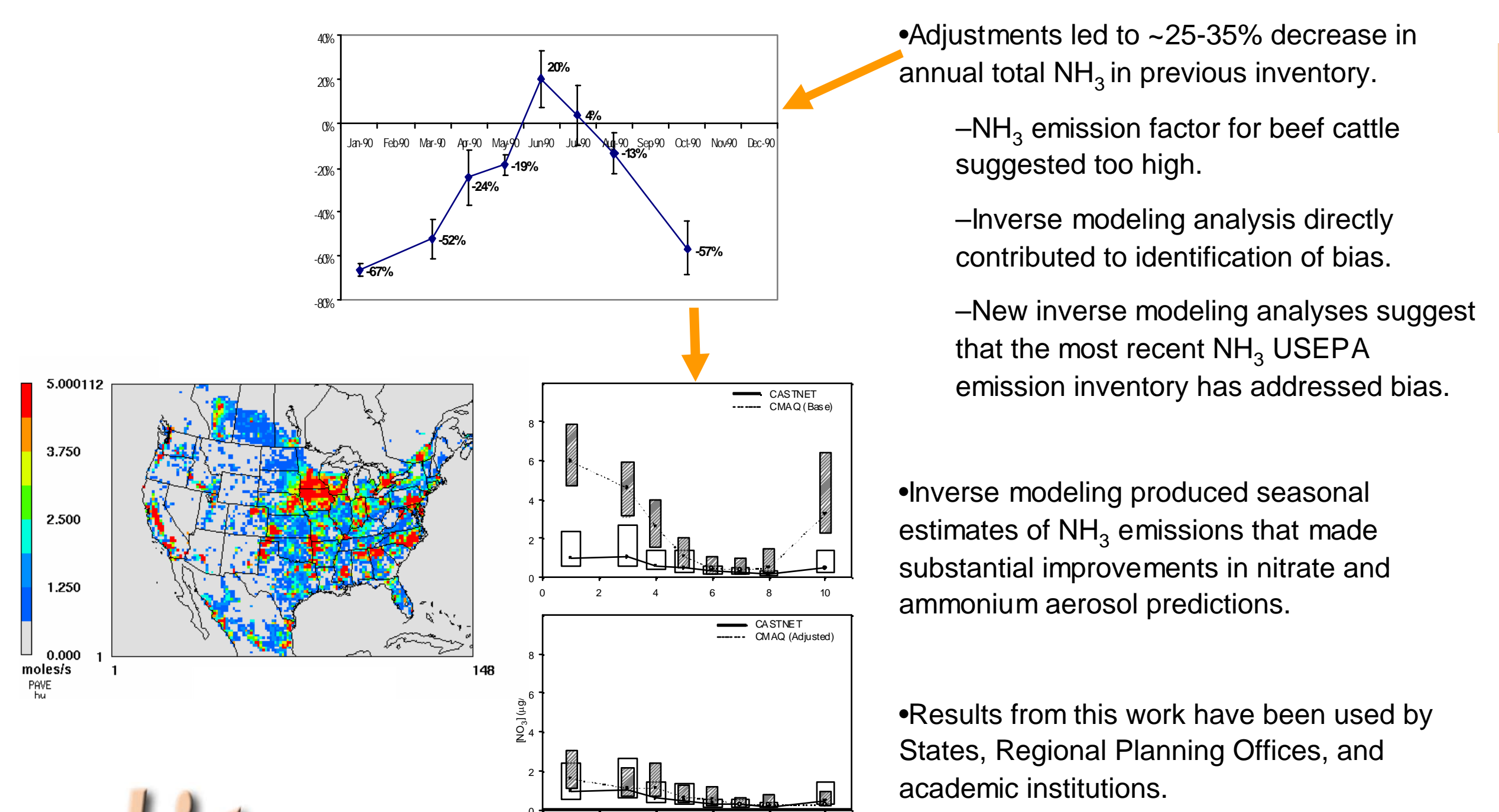## Result: Significant Difference in Source Apportionment Results

CMB-MM and CMAQ were applied to both Eastern Supersite Program (ESP) coordinated study periods (July 01/Jan. 02).

• Source apportionments show good monthly correlation, but lower on a daily basis.

• CMB-MM shows significant sensitivity to local sources and measurement uncertainties.

• CMAQ shows lower daily variability of source impacts.

CMB-MM / CMAQ

Legend: Other mass, Other OM, Meat cooking, Gasoline, Natural gas, Wood burning, Road dust, Diesel

Map legend: NH4HSO4, (NH4)2SO4, NH4NO3, SOC, Dust, Wood Burning, Pulp, Paper, Motor Vehicles, Unidentified

Source apportionment of total PM
▪ SOC : 40 ~ 60 % of OC (Seasonal change)
▪ Significant spatial variability

Result: Inverse modeling used to improve inventories

• Adjustments led to ~25-35% decrease in annual total NH_3 in previous inventory.

– NH_3 emission factor for beef cattle suggested too high.

– Inverse modeling analysis directly contributed to identification of bias.

– New inverse modeling analyses suggest that the most recent NH_3 USEPA emission inventory has addressed bias.

• Inverse modeling produced seasonal estimates of NH_3 emissions that made substantial improvements in nitrate and ammonium aerosol predictions.

• Results from this work have been used by States, Regional Planning Offices, and academic institutions.
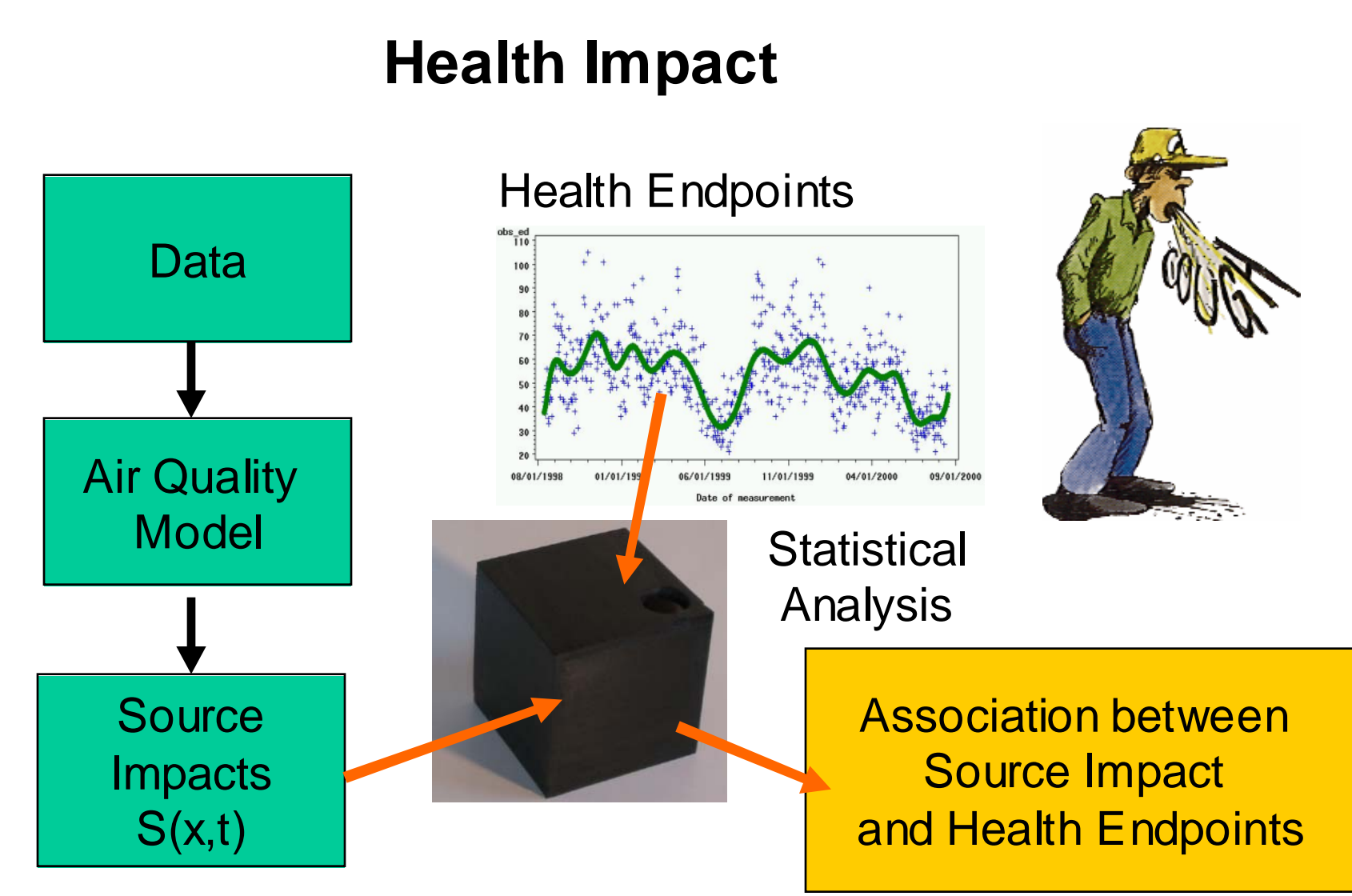
Future Directions

Our work has laid the foundation and developed tools for improving emissions inventories and source apportionments. We plan to extend the inverse modeling to multiple species across the U.S. The hybrid, iterative approach will used to develop source apportionments for the Eastern U.S. Markers will be added to CMAQ to conduct more detailed apportionments and better analyze the strengths and weaknesses of both the top-down and bottom up approaches. Our results will be used in epidemiologic analyses.

Impact and Outcomes

• This work has led to improvements in inventories being used and in assessing source impacts.

• The inventories and approaches are being used for SIPs and regional haze modeling.

Further Applications and Issues

Health Impact

Data → Air Quality Model → Source Impacts S(x,t) → Association between Source Impact and Health Endpoints

Health Endpoints

Statistical Analysis

Air Quality